

# (12) UK Patent Application (19) GB (11) 2 299 469 (13) A

(43) Date of A Publication 02.10.1996

(21) Application No 9603220.6

(22) Date of Filing 15.02.1996

(30) Priority Data

(31) 07070414 (32) 06.03.1995 (33) JP

(71) Applicant(s)

Kijima Co Ltd.

(Incorporated in Japan)

27-16, Minamimagome 6-chome, Oota-ku, Tokyo-to, Japan

(72) Inventor(s)

Seiichi Kijima

(74) Agent and/or Address for Service

Mewburn Ellis  
York House, 23 Kingsway, LONDON, WC2B 6HP,  
United Kingdom

(51) INT CL<sup>6</sup>

H02M 7/538 7/5383, H05B 41/29

(52) UK CL (Edition O)

H2H H88 HLD631 H23Y H25G H7B

H3P PAJT

H3T T1G3X T2B9 T2RX T2T3B T2W2 T2W3 T4P T4S

U1S S2125 S2126

(56) Documents Cited

GB 2254202 A

GB 2246034 A

GB 2244608 A

GB 2151090 A

EP 0408121 A2

EP 0124209 A1

(58) Field of Search

UK CL (Edition O) H2F FDXAXT FDXAXX, H2H HLD631

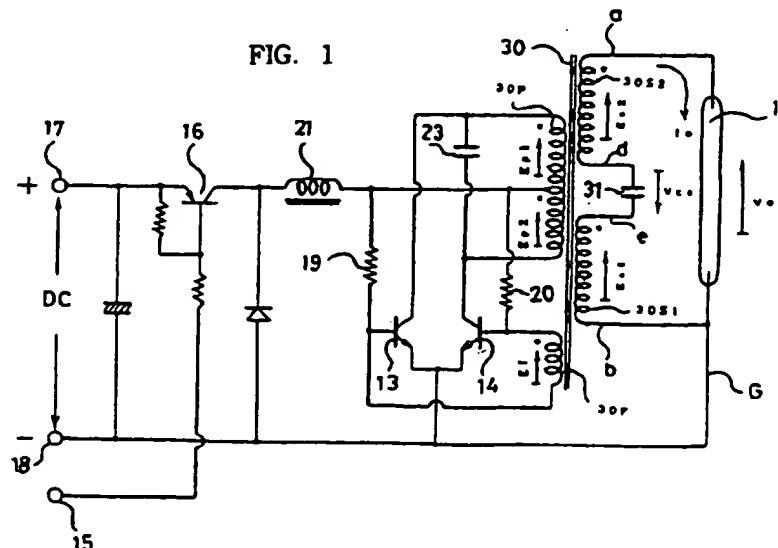
HLD639, H3P PAJT

INT CL<sup>6</sup> H02M 7/538 7/5383 7/5387, H05B 41/24

41/26 41/28 41/29

## (54) Output transformer arrangement for a push-pull inverter

(57) The output transformer 30 of a push-pull inverter has two output windings 30S1 and 30S2 having respective ends e and d connected to an impedance element 31 so that the windings are connected in series via the impedance element 31, the other ends b and a of the output windings 30S1, 30S2 being connected across a load 11 and one of such other ends b being at the same potential as the negative side 18 of a DC source which powers the inverter. This arrangement allows the dielectric strength of the transformer insulation to be reduced by one half compared to a conventional circuit (Fig.6) so that a small and thin transformer can be used. Leakage current and noise current are also reduced. Inner ends of the output windings may be connected to the impedance element and their outer ends connected to the load, or vice versa (Fig.3). The impedance element may be a capacitor 31, or a resistor, or an inductor (33, Fig.4). The load may be inductive or capacitive, or particularly a fluorescent lamp 11, such as a backlight for word processor or a computer.



GB 2 299 469 A

30)



2/7

FIG. 2

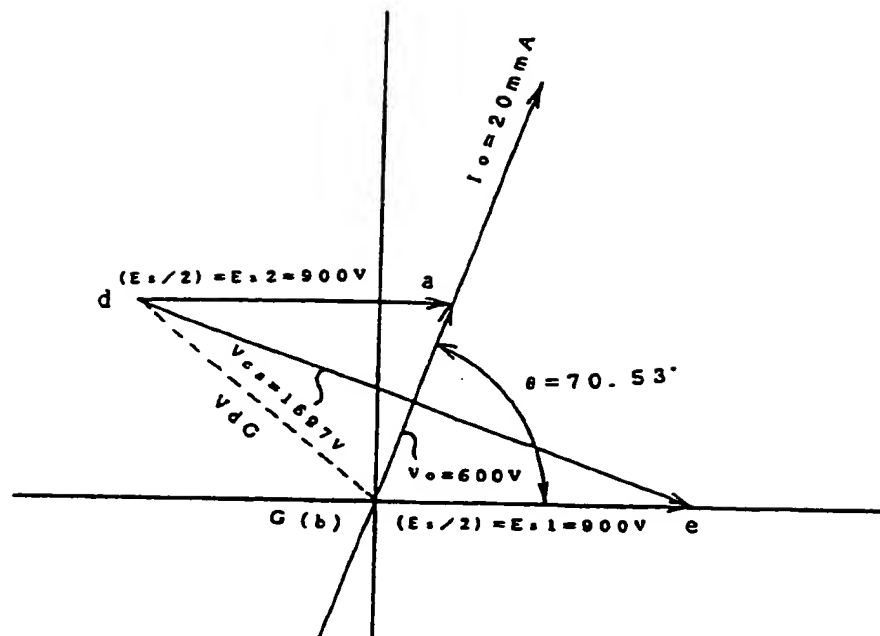
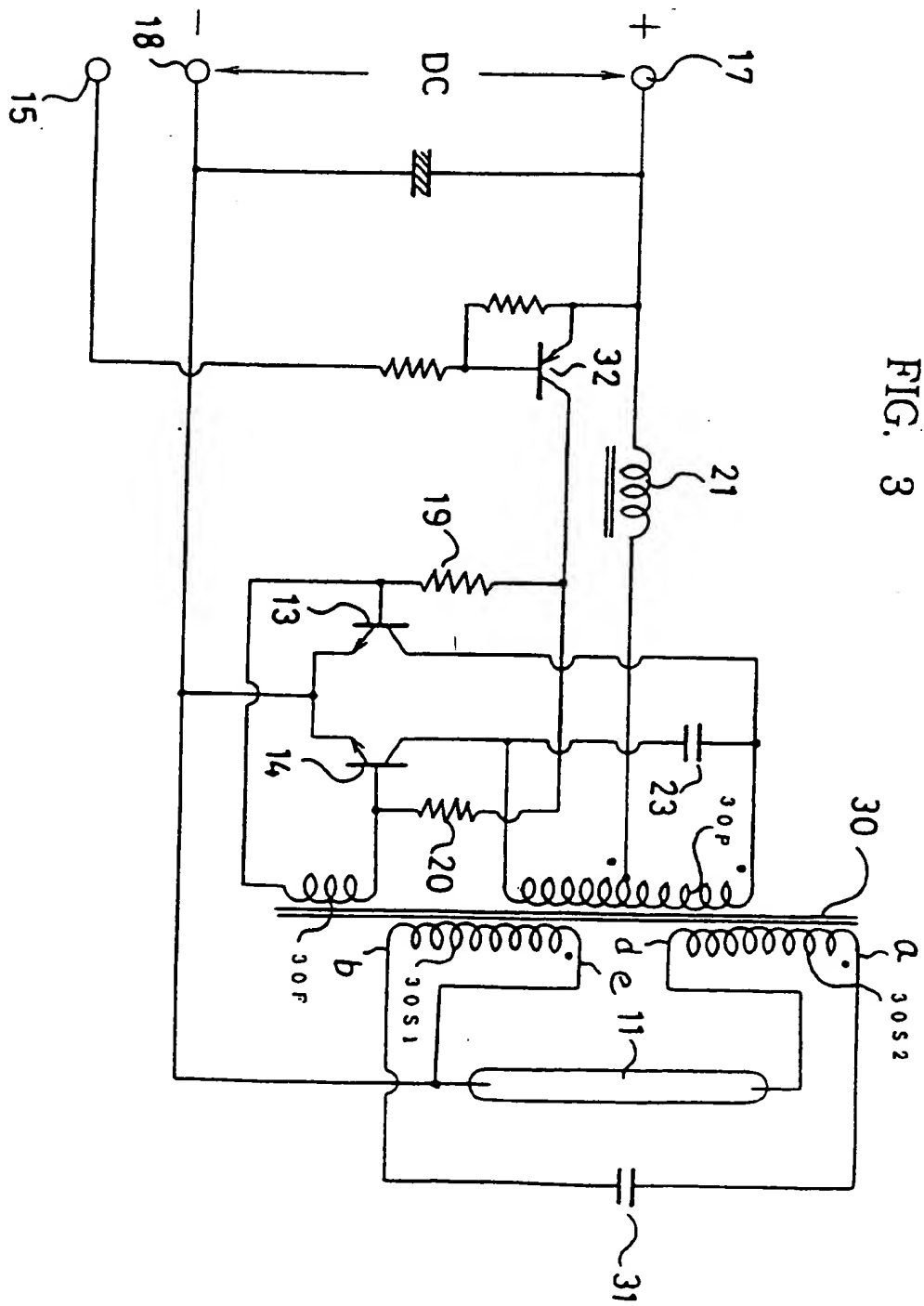
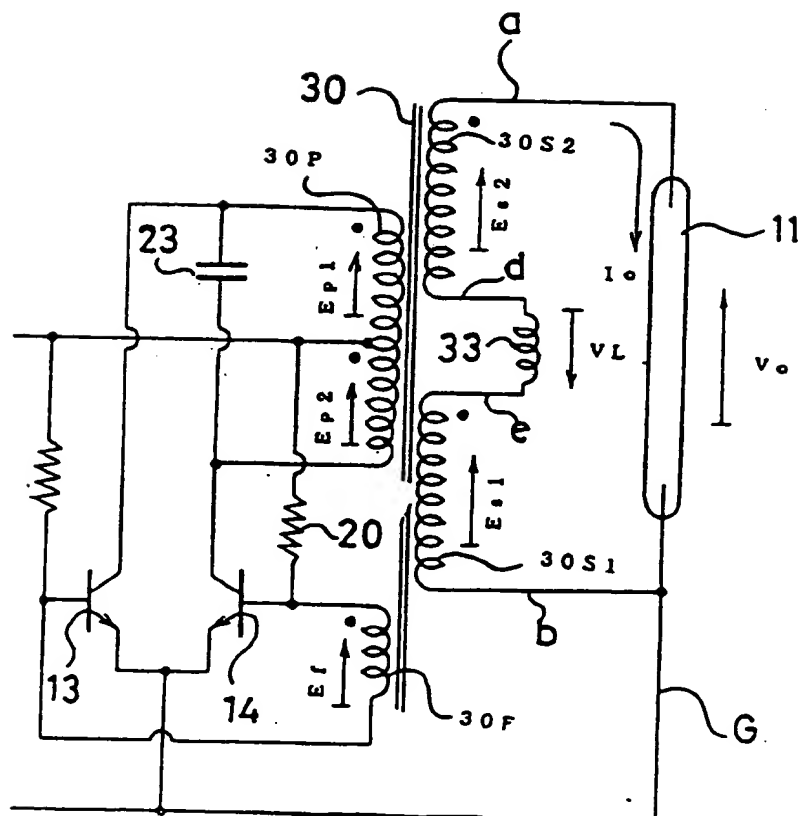


FIG. 3



4/7

FIG. 4



5/7

FIG. 5

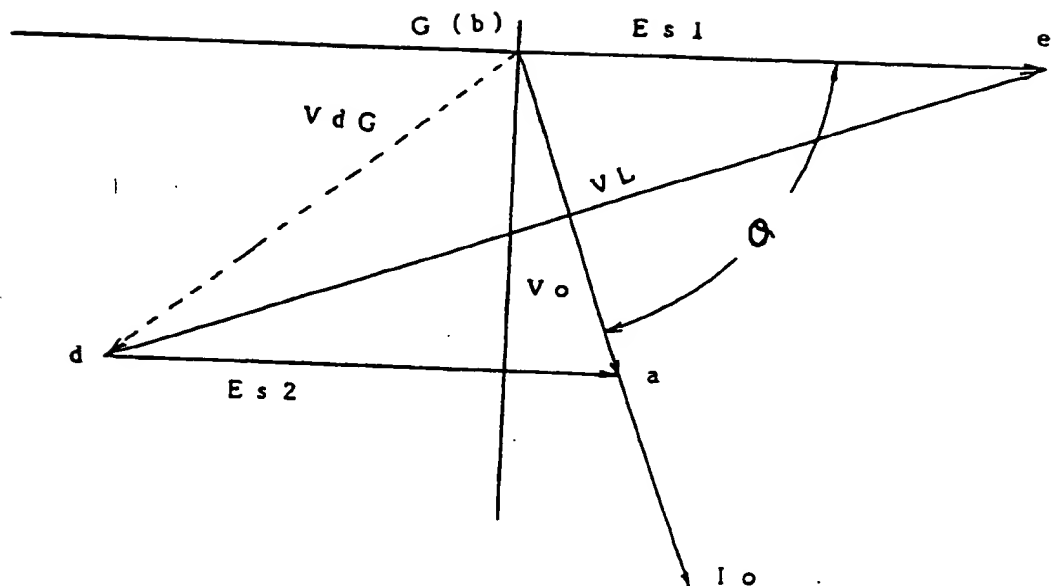
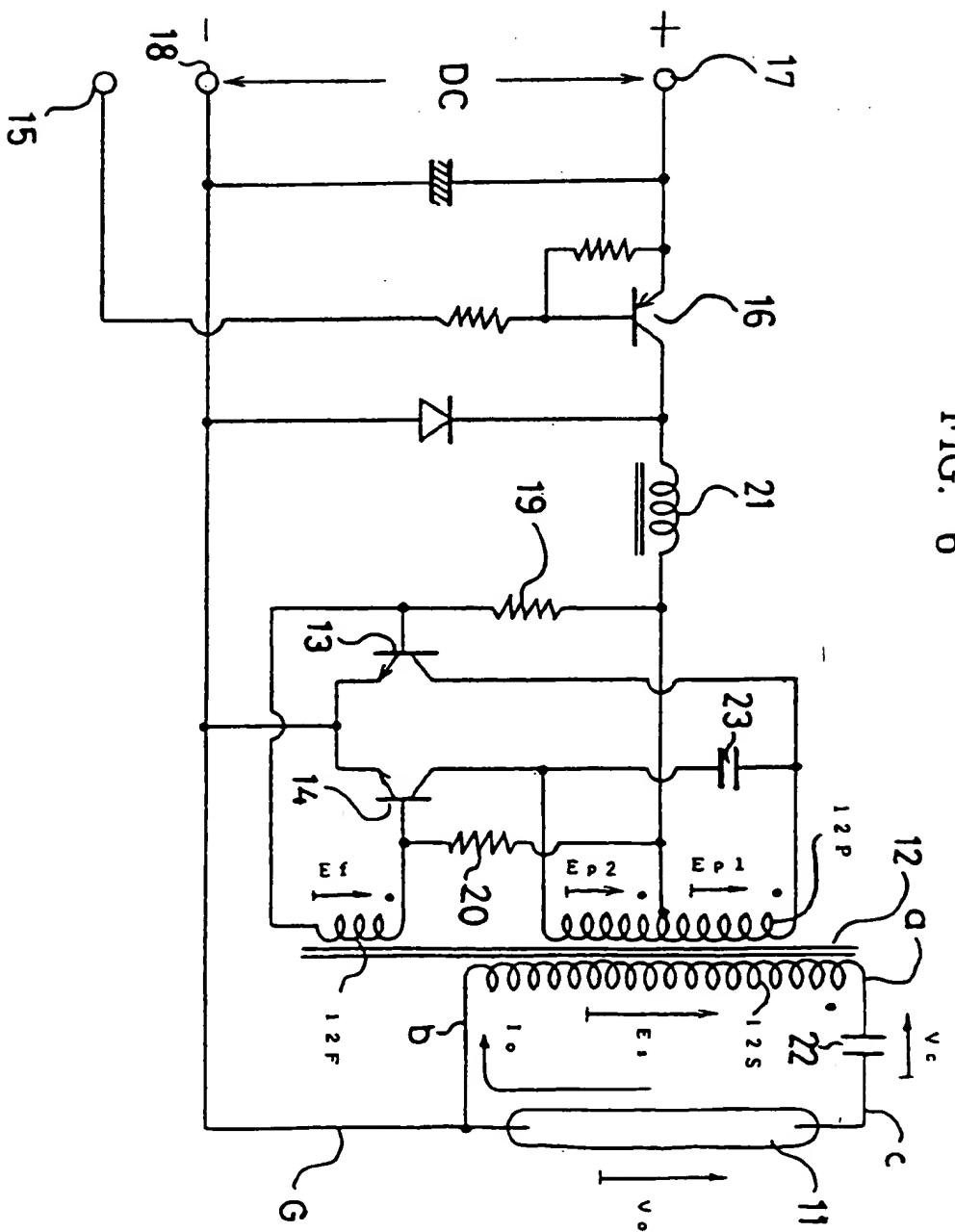
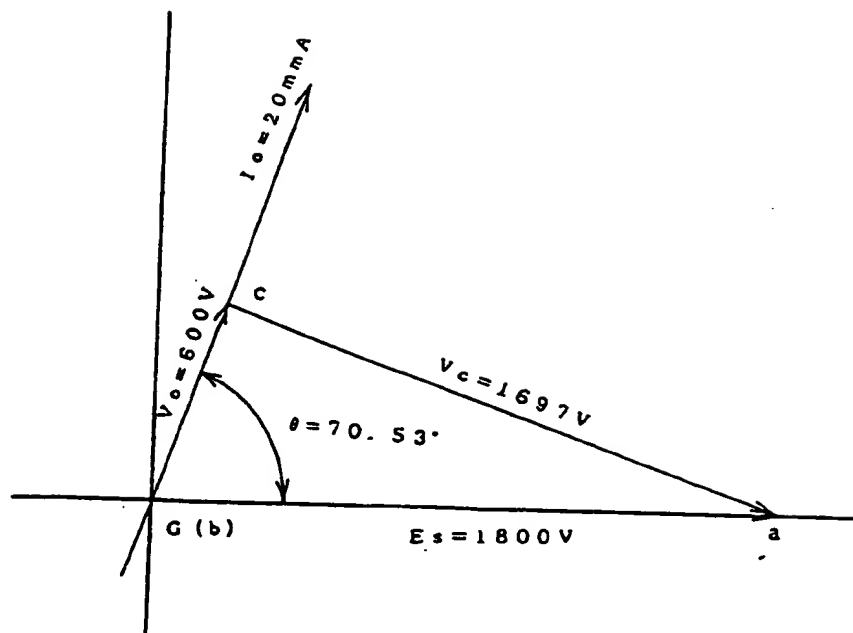


FIG. 6



7/7

FIG. 7





Push-pull inverter

BACKGROUND OF THE INVENTION

(Technical Field)

The present invention relates to a push-pull inverter used as a driver for cold-cathode discharge tube, hot-cathode discharge tube serving as so-called semihot, etc.

(Background Art)

Fig. 6 illustrates a conventional embodiment of the push-pull inverter constructed as the driver for a fluorescent lamp 11.

This inverter is provided with a push-pull inverter circuit substantially comprising a boosting transformer 12 and switching transistors 13, 14.

Upon application of a starting signal of low level from a terminal 15, a transistor 16 serving as a source switch is turned ON and supplied with DC power from a DC source connected to terminals 17, 18.

Then, the transistors 13, 14 are supplied through

starting resistors 19, 20, respectively, with their base current. Though both the transistors 13, 14 are consequently switched to their conductive states, they are different from each other in transistor characteristic and circuit arrangement so that one of them becomes more positively conductive than the other and said one transistor is turned ON earlier than the other.

For example, when the transistor 14 is turned ON earlier than the transistor 13, the current supplied from the DC source passes through a choke coil 21 into a primary coil (input coil) 12P of the transformer 12 at a center tap of said primary coil 12P and this primary coil 12P generates thereacross the voltages  $E_{p1}$ ,  $E_{p2}$  of direction as indicated by arrows in Fig. 6.

Since, at this time point, a tertiary coil (feedback coil) 12F generates thereacross voltage  $E_f$  of a direction as indicated by an arrow in Fig. 6, the base of the transistor 14 is affected by a positive feedback effect and the collector current of this transistor 14 rapidly increases.

Thereupon, a secondary coil (output coil) 12S generates thereacross inductive voltage of a direction as indicated by an arrow in Fig. 6, which is applied as

output voltage  $E_s$  from the transistor 12 to the fluorescent lamp 11 to initiate lighting of this fluorescent lamp 11.

It should be understood that the fluorescent lamp 11 is applied with tube voltage  $V_o$  and a ballast capacitor 22 generates thereacross charging voltage  $V_c$ .

Since increase in the current flowing through the transistor 14 is suppressed at a saturation point which depends upon a base current as well as an amplification degree, the voltage of a direction opposed to that as indicated by an arrow in Fig. 6 is generated across the primary coil 12P of the boosting transformer 12 and the transistor 14 is switched from ON to OFF while the transistor 13 is switched from OFF to ON, as said increase in the current is reduced.

When the transistor 13 is turned ON, the voltage of a direction opposed to that as indicated by an arrow in Fig. 6 is generated across the tertiary coil 12F and consequently the transistor 13 is affected by the positive feedback and the current flowing through the transistor 13 increases, resulting in that the inductive voltage of a direction opposed to that as indicated by an arrow in Fig. 6 is generated across the secondary coil 12S, which maintains lighting of the fluorescent lamp 11.

Thereafter alternate turning-ON of the transistors 13, 14 repeatedly occurs in the same manner as has been mentioned above, generating a high AC voltage across the secondary coil 12S.

It should be understood that a reference numeral 23 designates a resonant capacitor connected in parallel to the primary coil 12P in order to generate sine wave voltage.

Fig. 7 is a vector diagram illustrating a relationship established among the transformer output voltage  $E_s$ , the tube voltage  $V_o$  of the fluorescent lamp and the ballast capacitor voltage  $V_c$  during operation of said inverter under conditions as specified below:

Transformer output voltage  $E_s = 1800V$  (effective value)

(Peak-to-peak voltage  $E_p - p = 5091V$ )

Tube voltage  $V_o = 600V$  (effective value)

Tube current  $I_o = 20 \text{ mA}$  (effective value)

Tube power  $W_o = 12 \text{ W}$

Ballast capacitor voltage  $V_c = 1697 \text{ V}$  (effective value)  
(39.9 pF)

Output voltage frequency  $f = 47 \text{ kHz}$

Tube current phase angle  $\theta = 70.50^\circ$

As will be apparent from this vector diagram,  $E_s = V_o + V_c$  (It should be noted that this is a vector addition equation).

Said boosting transformer 12 is provided in the form of a miniaturized transformer comprising the primary coil 12P, the secondary coil 12S and the tertiary coil 12F lap-wound around a winding drum of a bobbin, a ferrite core partially inserted into said winding drum and terminal pins planted on the bobbin to which the respective coil ends are fixed by means of soldering or the like.

The inverter of such type is often used as a back light power supply for a display provided in word processor, personal computer or the like and, accordingly, the boosting transformer for such inverter is necessarily required to be as thin as possible.

Recently, considerably thinner boosting transformers have been developed and proposed. However, thinning as well as miniaturizing of the boosting transformer is limited by a problem such that a high DC output voltage (e.g., 600 to 3000 volts) required for such boosting transformer 12 inevitably makes a dielectric treatment difficult.

More specifically, in the boosting transformer 12 of

the above-mentioned construction, the low voltage side of the secondary coil 12S (output coil) is at a zero volt and the high voltage side is at several thousand volts, so said dielectric treatment among the primary coil 12P, the tertiary coil 12F, the terminal pins and the ground becomes more and more difficult as a configuration of the transformer is thinned.

Additionally, the boosting transformer of prior art has disadvantageously been prone to be affected by not only by leakage current due to a distributed capacity of the transformer 12 but also by noise generated from various components such as the fluorescent lamp, respective parts of the high voltage side and the lead wire.

#### SUMMARY OF THE INVENTION

In view of the stand of art as has previously been described, it is an object of the invention to develop a push-pull inverter allowing a boosting transformer to have a dielectric strength as low as possible so as to facilitate a configuration of the transformer to be thinned and miniaturized and allowing leakage current as well as noise to be effectively avoided.

The object set forth above is achieved, in accordance

with the invention, by a push-pull inverter having a boosting transformer and serving to boost an input voltage from a DC source and to convert it to AC voltage, said push-pull inverter being characterized by said boosting transformer provided with a first output coil and a second output coil between which an impedance element is connected so as to form together a serial circuit, wherein an output side of said first or second output coil is connected so as to have a same potential as a negative potential of the DC source and a load is connected to respective output sides of said first and second coils.

In said inverter, a sum of inductive voltages generated across the respective output coil sections is used as a total output voltage.

Consequently, the dielectric treatment may be made not against a high voltage of the output coil but against the voltage generated across each output coil section which is sufficiently lower than the voltage against which the dielectric treatment has conventionally been required.

In addition, both the leakage current and the noise current can be minimized, since the distributed capacity of the boosting transformer as well as the noise generated from the high voltage side depend on the inductive voltages

generated across the first and second output coils, respectively.

This is very advantageous to thin and miniaturize the boosting transformer.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described by way of example in reference with the accompanying drawings, in which:

Fig. 1 is a circuit diagram showing a first embodiment of the inverter constructed according to the invention;

Fig. 2 is a vector diagram illustrating transformer output voltage, tube voltage and coupling capacitor voltage in said first embodiment of the inverter;

Fig. 3 is a circuit diagram showing a second embodiment of the inverter constructed according to the invention;

Fig. 4 is a partial circuit diagram showing a third embodiment of the inverter constructed according to the invention;

Fig. 5 is a vector diagram illustrating transformer output voltage, tube voltage and coupling capacitor voltage in said third embodiment of the inverter;

Fig. 6 is a circuit diagram showing an inverter of prior art; and



Fig. 7 is a vector diagram illustrating transformer output voltage, tube voltage and coupling capacitor voltage in said inverter of prior art.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a circuit diagram showing a first embodiment of the invention in the form of a driver for fluorescent lamp and this embodiment is characterized by a boosting transformer 30. Rest of the circuit arrangement is similar to the well known inverter circuit as shown by Fig. 6 and therefore the components similar to those in the well known inverter circuit will be designated by similar reference numerals.

As shown, the boosting transformer 30 comprises a primary coil 30P, a first secondary coil 30S1, a second secondary coil 30S2 and a tertiary coil 30F.

In this boosting transformer 30, the first secondary coil 30S1 and the second secondary coil 30S2 both functioning as output coils are coupled to each other by a coupling capacitor 31 so that these output coils 30S1, 30S2 may form together with the capacitor 31 a serial circuit section.

In the above-mentioned boosting transformer 30, a fluorescent lamp 11 is connected to an output side b of the output coil 30S1, on one hand, and to an output side a of the output coil 30S2, on the other hand, wherein said output side b of the output coil 30S1 is connected so as to have a same potential (ground G) as a negative potential of a DC source.

Oscillation of the inverter constructed as has been described above causes the first and second secondary coils 30S1, 30S2 of the boosting transformer 30 to generate inductive voltages  $E_{s1}$ ,  $E_{s2}$ , respectively, and a sum of these inductive voltages  $E_{s1}$ ,  $E_{s2}$  is used as a total output voltage  $E_s$ .

Fig. 2 is a vector diagram illustrating respective voltages generated as the present embodiment of the inveter operates under conditions as specified below:

Total output voltage  $E_s$  of the transformer = 1800V  
(effective value)

(Peak-to-peak voltage  $E_p - p$  = 5091 V)

Output voltage  $E_{s1}$  of the first secondary coil 30S1 =  
900 V (effective value)

Output voltage  $E_{s2}$  of the second secondary coil 30S2 =  
900 V (effective value)

Tube voltage  $V_o = 600$  V (effective value)

Tube current  $I_o = 20$  mA (effective value)

Tube power  $W_o = 12$  W

Coupling capacitor voltage  $V_{ca} = 1697$  V (effective value), (39.9pF)

Output voltage frequency  $f = 47$  kHz

Tube current phase angle  $\theta = 70.53^\circ$

As will be readily understood from this vector diagram, both the output voltage  $E_{s1}$  of the first secondary coil 30S1 and the output voltage  $E_{s2}$  of the second secondary coil 30S2 function as an electromotive voltage while both the fluorescent lamp 11 and the coupling capacitor 31 function as a load, so  $E_{s1} + E_{s2} = V_o + V_{ca}$  and therefore  $(E_s/2) + (E_s/2) = V_o + V_{ca}$  (It should be understood that these are vector addition equations).

In this manner, the coupling capacitor 31 functions to halve the output voltage and at the same time functions as a ballast capacitor.

Thus, here is established a relationship expressed by  $E_{s1} = E_{s2} = 900$  V ( $V_p - p = 2545.5$  V) which means that a dielectric strength required for insulation of the transformer may be reduced by half relative to the dielectric strength which has been required by the

embodiment of prior art.

As a result, an arrangement for dielectric treatment can be simplified and thereby a configuration of the transformer can be effectively thinned and miniaturized without leakage current due to the distributed capacity as well as noise generated from the high voltage section.

So far as it is not pursued to obtain an extremely thinned and small-sized configuration of the transformer, the respective output coil voltages, i.e., the total output voltage  $E_s$  can be set at a sufficiently high level to use the inverter as the driver for the fluorescent lamp of high tube voltage.

Fig. 3 is a circuit diagram showing a second embodiment of the inventive inverter, in which the fluorescent lamp 11 is connected between an end d of the first secondary coil 30S1 and an end e of the second secondary coil 30S2 while the coupling capacitor 31 is connected between the other ends a and b of these secondary coils 30S1, 30S2.

There is provided a starting transistor 32 so that the bases of the switching transistors 13, 14 may be supplied with starting current upon turning-ON of said starting

transistor 32.

Rest of the circuit arrangement is similar to the first embodiment.

This second embodiment operates in the same manner as the first embodiment and therefore its manner of operation will not be described here.

Fig. 4 is a partial circuit diagram showing a third embodiment of the inventive interter, in which the first secondary coil 30S1 is connected to the second secondary coil 30S2 by a coil element 33. Rest of the circuit arrangement is similar to the inverter circuit shown by Fig. 1.

According to this embodiment, the tube current  $I_o$  lags relative to the output voltages  $E_{s1}$ ,  $E_{s2}$ , so the output voltages  $E_{s1}$ ,  $E_{s2}$ , the tube voltage  $V_o$  and the coil element voltage  $V_L$  establish among them a relationship illustrated by a vector diagram of Fig. 5 and expressed by a vector addition equation  $E_{s1} + E_{s2} = V_o + V_L$ .

In consequence, the previously mentioned relationship expressed by  $(E_s/2) + (E_s/2) = V_o + V_L$  (vector addition equation) is established also in this embodiment and the

same effect as obtained by the previously mentioned first and second embodiments can be obtained also by this third embodiment.

While the invention has been described hereinabove with respect to several specific embodiments, it is also possible without departing from the scope of the invention to connect the first secondary coil 30S1 to the second secondary coil 30S2 of the boosting transformer 30 by a resistor element so far as more or less decrease of the inverter efficiency is tolerated.

It should be also understood that the boosting transformer 30 is not limited to the arrangement providing  $E_{s1} = E_{s2}$  but may be alternatively arranged so as to provide  $E_{s1} > E_{s2}$  or vice versa.

When the inverter of the invention is used as the driver for a lighting discharge tube as in the above-mentioned embodiments, this inverter can be used also as a dimmer by changing a duty ratio of pulses provided from the terminal 15.

Furthermore, it is unnecessary to modify the basic arrangement of the inverter depending on the associated load which may be resistive load such as fluorescent lamp

or inductive or capacitive load.

WHAT IS CLAIMED IS:

1. Push-pull inverter having a boosting transformer and serving to boost an input voltage from a DC source and to convert it to AC voltage, said push-pull inverter being characterized by said boosting transformer provided with a first output coil and a second output coil between which an impedance element is connected so as to form together a serial circuit section, wherein an output side of said first or second output coil is connected so as to have a same potential as a negative potential of the DC source and a load is connected to respective output sides of said first and second output coils.
2. Push-pull inverter according to Claim 1, wherein any one of capacitor, coil and resistor is connected between said first and second output coils as said impedance element.
3. Push-pull inverter according to Claim 1, wherein a fluorescent lamp is connected to output sides of said first and second output coils as said load.
4. Push-pull inverter according to Claim 1, comprising an input coil having a center tap, said boosting transformer provided with said first and second output



coils, a first transistor adapted for switching input current flowing through said center tap into one side of said input coil, a second transistor adapted for switching input current flowing through said center tap into the other side of said input coil, a capacitor connected between said first and second output coils, and a fluorescent lamp connected to the respective output sides of said first and second output coils.

5. Push-pull inverter according to Claim 4, wherein said push-pull inverter functions also as a dimmer of the fluorescent lamp by operating said first and second transistors with pulses having a duty ratio adjustably varied.

6. A push-pull inverter for providing an AC voltage from a DC supply, the inverter comprising drive circuitry for supplying drive current pulses to first and second input coil windings of a transformer, the transformer having first and second output coil windings connected in series through an impedance element, and having output connections for connection to a load, an output connection of one of said first and second output coil windings being connected to have substantially the same potential as a positive or negative potential of said DC supply.

7. A push-pull inverter according to claim 6, wherein said first and second input coil windings are connected in series, each winding comprising one half of an input coil having first and second ends and a centre tap.

8. A push-pull inverter according to claim 7, wherein said centre tap is coupled to one potential of said DC supply, and said first and second ends are coupled via switching elements to another potential of said DC supply .

9. A push-pull inverter according to claim 8, wherein said switching elements are NPN transistors connected between said input ends and a negative potential of said DC supply, said centre tap being coupled to a positive potential of said DC supply.

10. A push-pull inverter according to any one of claims 6 to 9 wherein a fluorescent lamp is connected between said output connections as said load.

11. A push-pull inverter substantially as herein described, or as illustrated in Figs. 1-5 of the accompanying drawings.